MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. LXXV. NOVEMBER 13, 1914. NO. 1

Professor H. F. NEWALL, M.A., D.Sc., F.R.S., VICE-PRESIDENT, in the Chair.

Walter S. Adams, M.A., Solar Observatory, Mount Wilson, California, U.S.A.;
Henri Andoyer, Professeur à la Sorbonne, Paris; and
Frank Schlesinger, M.A., Ph.D., Allegheny Observatory, U.S.A.,

were balloted for and duly elected Associates of the Society.

The following candidates were proposed for election as Fellows of the Society, the names of the proposers from personal knowledge being appended:—

George Beaver Croucher, F.R.G.S., Principal, Grimsby Navigation School and Technical School for Fishermen, Grimsby (proposed by O. T. Olsen);
Thomas Henry Dean, Edenthorpe, Anderton Road, Sparkbrook, Birmingham (proposed by W. G. Hooper);
Algernon Charles Gifford, M.A., Wellington College, Wellington, New Zealand (proposed by J. W. Nicholson);
John G. Howarth, B.A., Science Master, Reigate Grammar School, Dane's Dyke, Reigate, Surrey (proposed by S. T. Klein);
Harold Jeffreys, B.A., M.Sc., Isaac Newton Student, St. John's College, Cambridge (proposed by H. F. Newall);
James Knight, M.A., D.Sc., F.R.S.E., F.C.S., F.G.S., Royal Philosophical Society, Glasgow (proposed by R. R. Agnew);

John Earle Maxwell, 84 Dartmouth Road, Cricklewood, N.W. (proposed by A. H. Fison);
Clive Nossiter, Acting First Assistant, Perth Observatory, Western Australia (proposed by H. B. Curlewis); and
William Marshall Smart, M.A., B.Sc., Trinity College, Cambridge (proposed by A. S. Eddington).

One hundred and twenty-nine presents were announced as having been received since the last meeting, including, amongst others:—

A. S. Eddington: Stellar movements and the structure of the Universe, presented by the author; Greenwich Astrographic Catalogue, vol. iii., presented by the Royal Observatory; A series of eleven mounted prints of Solar prominences, Nebulæ, etc., taken by E. E. Barnard and F. Slocum at the Yerkes Observatory, presented by Professor Frost.

Astrographic Chart: Sixteen charts from the Algiers and Paris Observatories, presented by the French Minister of Public Instruction, and twenty charts from the Specola Vaticana, Rome.

A marble bust of George Bishop, with pedestal, presented by Major Charles W. Bishop.

Note on the Meaning of the so-called Third Star Stream Drift O.
By H. H. Turner, D.Sc., F.R.S., Savilian Professor.

1. My perusal of Professor Eddington's fascinating book, *Stellar Movements and the Structure of the Universe*, has been as yet only hasty, owing to circumstances incidental to the Australian visit of the British Association. But I will venture to indicate answers to two of the questions he asks at the top of p. 256. I think I can answer most of the others, but the answers would be more speculative.

(*a*) *How are the two Star Streams to be explained?*

The answer to this question has already been given in *Monthly Notices*, lxxii. pp. 387 and 474, and is duly noted by Professor Eddington on p. 257 of his book. Briefly, the answer is that a large number of stars are oscillating "to and fro" through the centre of the whole system, under the attraction of the whole system. One "star-stream" is simply the general aggregate of all stars moving "to" the centre, the other star stream the aggregate of those moving "fro."

(*b*) *What is the Meaning of the Third Stream Drift O?*

This is the main point of the present note. The answer given must of course be consistent with that given to question (*a*); and at first sight it would appear that that answer leaves no room for a third stream. But a little consideration shows that, on the contrary, the answer to (*b*) is directly suggested by the answer to (*a*).

The key to the situation is that Drift O is practically *at rest in space.* Now, in a system of stars oscillating "to and fro" there must be a number which are at the moment moving neither to nor fro, but pausing. It is a familiar fact that the time spent in these pauses is considerable, though we may not be able to estimate it quantitatively, from ignorance of the law of force. That law depends on the distribution of stars in the cluster, which may not yet have even reached a "steady" state. All we can say is that it is probably somewhere between the inverse square of the distance (corresponding to infinite concentration at the centre) and the direct distance (corresponding to uniform distribution in a sphere), though the existence of an outer ring of stars may carry it past the second limit. But taking these two cases for illustration, we know how, in the former case, a comet (moving under the inverse square law) loiters at aphelion. When making his calculations on Halley's Comet, Dr. Cowell commented on the fact that it spent half its time beyond the orbit of Neptune. A pendulum illustrates the second case—we can see it for ourselves pausing at the ends of its swing. The pause is less marked in this case, but might be accentuated by the attraction of the ring.

If, then, stars are oscillating to and fro in elongated orbits, a number of them will at any given moment be pausing, temporarily at rest in space, or at any rate at rest relatively to the general body of stars, which is all we have to go by. My answer to question (*b*) is that Drift O is merely the general aggregate of these stars at apcentron. If the stars of this drift are more distant than the average, this character would accord well with the notion of stars at their limiting distances from the centre.

There is, however, one further characteristic of Drift O which must be considered: I quote Professor Eddington's account of it (p. 124):—

"There is, however, an important property of Drift O, which seems to make it something more than a mathematical abstraction. We have seen that all the stars of the Orion type appear to belong to it, and not to the other two drifts. It is true that in addition it contains stars of the other types, which are not in any way distinctive; but that it should contain the whole of one spectral class seems to show that it corresponds to some real physical system, and places it on a somewhat different footing from the two older drifts, for which we have as yet failed to find any characteristic apart from motion."

It was pointed out in *Monthly Notices*, lxxii. pp. 406–7, that the motion of a nebula or system under its own attraction from rest would tend to be isochronous. It would tend to collapse to the centre so that all its parts reach the centre together. At some epoch the congestion would become so great as to cause explosion, which would scatter the fragments outwards again. The isochronic property would then bring them all to apcentron at about the same time.

My answer about Drift O must thus be amplified by saying

that the Orion stars are probably the product of some explosion of this kind at such a date that the stars are now in apcentron. They are not by any means the only stars in apcentron, as is noted in the above extract; but they retain marks of their common origin in their common spectral type and their common pause.

University Observatory, Oxford.

The Absorption of Light in Space.

By H. S. Jones, B.A., B.Sc.

(*Communicated by the Astronomer Royal.*)

In a paper published in the *Monthly Notices*, January 1914, were given the values of the proper motions of over 650 stars within 17° of the pole derived by the author for the purpose of discussing them in relation to their spectral type. The stars used were those in Parkhurst's *Yerkes Actinometry*,* for which accurate values of both the photographic and visual magnitudes had been obtained, and for which the spectral types also were given. The purpose of the present paper is to use these proper motions, and the values of the photographic and visual magnitudes, and the spectral type determinations as material for obtaining evidence as to whether there exists any absorption of light in space; and, if so, of what magnitude. A considerable amount of evidence has been collected within recent years in favour of the view that such an absorption does exist; some of the early determinations indicated quite a large value, of the order of $0^m{\cdot}20$ in a distance of 10 parsecs. Kapteyn has shown that such values are untenable, as they necessitate a star density increasing very rapidly with increasing distance from the sun. Even a value of the order of $0^m{\cdot}03$ is very improbable. Kapteyn, by the method indicated below, obtained a very much smaller value, but the probable error attaching to it was relatively very large. Other methods have their results rendered difficult of interpretation owing to the fact that various assumptions must be made in order that the results obtained can be attributed to absorption of light in space, such as the assumption that for faint stars the relative numbers of the various spectral types is the same as for the bright stars, or the assumption that the results obtained from stars of widely differing absolute luminosity are directly comparable. The fact remains that the amount of the absorption is still unknown with any degree of certainty, yet a knowledge of its magnitude is of fundamental importance in stellar statistics.

The method invented by Kapteyn appears, at the present time, to offer most advantages. He assumes that the colour index of a star is expressible in the form

$$\text{Colour index} = a + bm + c\mathrm{M} + d\Delta,$$

* *Astroph. Journ.*, xxxvi. p. 169, 1912.

in which a is a constant, dependent upon the spectral type, b, c denote the increase in redness for unit increase in the apparent and absolute magnitudes (m, M) respectively. Δ is the distance of the star, and $d\Delta$ is the difference in the photographic and visual absorption in traversing this distance. Equations similar to these are derived for each star, and then combined into groups according to spectral type, and the magnitude of the proper motion: in this way a and b are eliminated and the resulting equations solved by the method of least squares in order to obtain c and d. The individual distances of the stars used are not, of course, known: Kapteyn assumed for each group a mean parallax, derived from the tables in *Groningen Publications*, No. 8, knowing the mean magnitude and proper motion, and from this mean parallax the mean distance was obtained. This method of obtaining the mean distance is open to objection, inasmuch as it tacitly assumes that the stars of different spectral types are distributed in the same way throughout space; and, as is well known, this is very far from being the case.

The unit of distance being 10 parsecs (corresponding to a parallax of $0''{\cdot}1$), Kapteyn * found that

$$c = +0{\cdot}0058 \pm 0{\cdot}0112,\ d = +0{\cdot}0039 \pm 0{\cdot}0018.$$

The probable error of c being much larger than the value itself, Kapteyn assumed c to be zero, and so obtained a value for d with a much smaller probable error, viz. $d = +0{\cdot}0031 \pm 0{\cdot}0006$.

The method used by Kapteyn has been followed with a few modifications in the present paper.

Before proceeding to the derivation of a value for the absorption, it is of interest to investigate what information the results of Parkhurst give as to a phenomenon which is now tolerably well established—that on the average the apparently fainter stars are the redder. Parkhurst gives the mean values of the colour indices for each spectral type: the deviations from these means were grouped according to the visual magnitude, with the results shown in Table I.

Table I.

Limits of Magnitude.	No. of Stars.	Mean Deviation.
		m
4·00–4·50	7	−0·09
4·51–5·00	10	−0·05
5·01–5·50	29	−0·07
5·51–6·00	35	−0·03
6·01–6·50	88	+0·01
6·51–7·00	133	+0·04
7·01–7·50	140	+0·03
7·51–8·00	142	+0·03

* *Loc. cit.*, p. 316 (with correction for mean distance applied, as obtained on p. 399).

In spite of a slight irregularity, there is evidently a well-marked tendency for the mean deviation to increase with increasing magnitude: in other words, for the fainter stars the colour index is relatively larger on the average than for the brighter stars, or, as expressed above, on the average the apparently fainter stars are the redder. This may be due in whole or in part to absorption of light, the fainter stars being on the average the most distant, or it may be due to an effect of the apparent magnitude upon the colour index, as expressed by the b term above, due to the fact that the scale of the photographic and visual magnitudes are not quite the same. The value of b obtained below indicates that this may be the explanation.

For the subsequent discussion the stars were divided into five groups with the following spectral limits:—(i.) B8 – A4; (ii.) A5 – F0; (iii.) F1 – F9; (iv.) G0 – G5; (v.) G6 – K5. By sub-dividing in this way, each group contains sufficient stars upon which to base a discussion, and at the same time in no group is the spectral range very large. From the original list of stars, a number were rejected for which the derived proper motions were weak, and only those whose proper motions were based upon positions in several catalogues, and which were well determined, were retained. Each of the above groups was then further divided into two sub-groups, of larger and smaller proper motion respectively, the limits of proper motion separating these sub-groups being in each case so chosen that they contained approximately equal numbers of stars. Table II. gives the results so obtained.

TABLE II.

Spectral Limits.	Limits of P.M.	Mean Centennial P.M.	Mean Vis. Mag.	Mean Colour Index.	$\bar{v}$.	No. of Stars.
		"	m	m	"	
B8 – A4	<0·030	2·1	6·73	+ ·048	2·34	73
	>0·030	5·6	6·43	+ ·022		72
A5 – F0	<0·060	3·3	7·13	+ ·291	3·65	26
	>0·060	11·0	6·64	+ ·272		33
F1 – F9	<0·090	4·7	6·96	+ ·495	5·52	35
	>0·090	17·4	6·86	+ ·510		31
G0 – G5	<0·050	2·8	6·80	+1·004	3·72	49
	>0·050	12·9	6·53	+ ·965		48
G6 – K5	<0·030	1·7	6·40	+1·482	2·08	35
	>0·030	6·4	6·24	+1·382		40

The first five columns in the above table are self-explanatory. The sixth column contains the mean value of the components of the centennial proper motion towards the solar apex, whose

position was taken to be R.A. 270°, Dec. +34°. From this mean component the mean parallactic motion can be derived. The last column gives the number of stars upon which the means are based.

Before proceeding further it is necessary to correct the values obtained for the mean colour indices of each group, so as to free them from the effects of a systematic error whose effect is to make the difference in the mean colour indices of the stars of small and of large proper motion too small for the blue stars, and too large for the red stars. This arises in the following way: Owing to errors of classification, there will necessarily be included in the group of stars of type B8 – A4 some whose spectra are in reality of earlier type than this, and some which are in reality of later type. The colour indices of the earlier stars are relatively small, and those of the later stars relatively large as compared with the B8 – A4 stars. But the average proper motion of the B stars is much smaller than that of the A stars. Hence, of the B8 – A4 stars, those of small proper motion will, owing to errors of classification, contain a relatively large number of the wrongly included earlier B stars, which will make the mean colour index too small; and the stars of large proper motion will contain a relatively large number of the wrongly included later A stars, which will cause the mean colour index for these stars to be too large. Therefore for both reasons the difference in the two means will be too small. At the other end of the table this effect works in the opposite direction, owing to the mean proper motion of the earlier G stars being larger than that of the later K stars, and the difference of the two means there given will be too large.

The probable error in the classification can be estimated as follows: Parkhurst gives for the probable errors of a determination of a photographic and a visual magnitude the values $\pm 0^m{\cdot}03$ and $\pm 0^m{\cdot}04$ respectively. It follows that the probable error of a determination of colour index is $\pm 0^m{\cdot}05$. Also, if unit spectral interval be taken as that between Classes B and A, A and F, F and G, etc., Parkhurst's figures show that to each interval corresponds in the mean an increase of colour index of amount $0^m{\cdot}46$, or to each tenth interval (A0 – A1, etc.) corresponds an increase of amount $0^m{\cdot}046$. Therefore the probable error of a determination of colour index or of spectral type is ·11 intervals. Taking this amount to represent the probable error in spectral classification, it follows that of the stars classified as of a certain type (say F0), in reality only the fraction 0·241 belong to this class, the fraction 0·200 belongs to each of the two classes one-tenth interval removed (A9 and F1), the fraction 0·116 to each of the classes A8 and F2, and so on.

To apply the correction it was necessary to draw up a table giving for each spectral type the proportion of stars between any determined limits of proper motion. This table was based upon the Parkhurst stars alone, so as to represent stars of the same mean magnitude as those used in the present discussion. The values for each spectral class were smoothed, and where, for any class,

not sufficient values were obtainable, values were assigned by interpolation between adjacent classes.

Taking then, for example, the group of stars A5 – F0, the percentage belonging to each class being obtained from the observed figures, it is easy to calculate the distribution of this group amongst the various spectral types when freed from errors of classification. The figures in this case are given in Table III.

TABLE III.

Type.	Per cent.	Type.	Per cent.
A0	·05	A8	12·86
A1	·41	A9	11·77
A2	1·51	F0	9·96
A3	4·17	F1	6·88
A4	7·95	F2	3·64
A5	11·70	F3	1·38
A6	13·59	F4	·32
A7	13·65	F5	·05

The percentages of each of these classes with proper motions greater and less than 0″·060 being known, as also the average value of the colour index for each type, it is easy to calculate the average colour index for the stars observed as of types A5 – F0, and with proper motions $>0''{\cdot}060$, and also for stars of the same type with proper motions $<0''{\cdot}060$. The means in the two cases would be the same if there were no errors of classification, and so it is easy to deduce the corrections to apply to the mean colour indices in the two cases so that the average value for the two classes together is unaltered.

The corrections which must be applied to each group were completed in this way, and the results obtained are given in Table IV.

TABLE IV.

Spectral Type.	Limits of P.M.	Correction to Mean Colour Index.
B8 – A4	$<0''{\cdot}030$	+ ·027
	$>0''{\cdot}030$	– ·030
A5 – F0	$<0''{\cdot}060$	+ ·018
	$>0''{\cdot}060$	– ·022
F0 – F9	$<0''{\cdot}090$	+ ·004
	$>0''{\cdot}090$	– ·005
G0 – G5	$<0''{\cdot}050$	– ·007
	$>0''{\cdot}050$	+ ·008
G6 – K5	$<0''{\cdot}030$	– ·017
	$>0''{\cdot}030$	+ ·014

The stars used being in a small area of the sky around the north pole, the mean apical component of proper motion when divided by the sine of the mean angular distance from the solar apex gives the mean parallactic motion M, from which the mean parallax for the group is obtained from the relation

$$M'' = 410\,\bar{\pi},$$

M″ being expressed in seconds of arc per century.

Although this is a legitimate method of deriving the parallax of each group taken as a whole, it is not correct to apply it individually to the sub-groups, for the following reason: Consider two stars having the same peculiar proper motion, but the one moving in the same direction as the solar system and the other in the opposite direction; then the former will appear to have a smaller proper motion than the latter, and if their peculiar proper motion is somewhat larger than the limit separating the two sub-groups, it may fall into the group of small proper motion; whilst if the peculiar motion is somewhat smaller than the limit, the star of apparently larger proper motion may fall into the group of large motions. Thus there will be a tendency for the apparently slow-moving group to contain a relatively large number of stars moving in the same direction as the solar system, and for the apparently fast-moving group to contain a relatively large number of stars moving in the opposite direction, so that when the mean is taken, the peculiar motions will not average to zero, and the mean parallactic motion obtained for the group of small proper motion will be smaller, and that for the other group larger than it should be.

The procedure adopted by Kapteyn was to adopt for each group mean parallaxes derived from the Groningen tables, from a knowledge of the mean magnitude and proper motion. This involves the assumption that the mean parallaxes of stars of each separate type can be represented in a single table. In the present paper the actual values of the mean parallaxes have not been adopted from Kapteyn's tables, but the values assigned to each pair of sub-groups have been such that whilst their ratio is equal to the ratio of the parallaxes as given by Kapteyn, their mean value agrees with the mean parallax as derived for the whole group from the parallactic motion. This method should lead to values which are very near the truth.

To change from the mean parallax to the mean distance the assumption was made that these stars are distributed in space according to the law $2k^2re^{-k^2r^2}dr$ for the fraction between distances r and $r+dr$. This law has been shown by Dyson to be a very good approximation for the stars in this region of the sky. The unit of distance being taken to correspond to a parallax of 1″ (one parsec), the mean parallax is

$$\bar{\pi} = 2k^2\int_0^\infty e^{-k^2r^2}dr = k\sqrt{\pi},$$

and the mean distance $\bar{\Delta}$ is

$$\bar{\Delta} = 2k^2 \int_0^\infty r^2 e^{-k^2 r^2} dr = \sqrt{\pi}/2k,$$

so that

$$\bar{\Delta} = \pi/2\bar{\pi}.$$

If the unit of distance is 10 parsecs, the value so derived must be divided by 10. With this unit the absolute magnitudes of the stars can be calculated by means of the formula

$$\mathrm{M} = m + 5 + 5 \log \pi.$$

In this way the results given in Table V. were obtained.

TABLE V.

Spectral Limits.	Limits of P.M.	Mean Visual Mag.	Mean Corrected Colour Index.	$\bar{\pi}$.	$\bar{\Delta}$.	Mean Absolute Mag.
	"	m	m	"		m
B8 – A4	<0·030	6·73	+ ·075	·00466	33·8	+0·07
	>0·030	6·43	− ·008	·00931	16·9	+1·27
A5 – F0	<0·060	7·13	+ ·309	·00643	24·4	+1·17
	>0·060	6·64	+ ·250	·01527	10·3	+2·55
F1 – F9	<0·090	6·96	+ ·499	·00938	16·7	+1·82
	>0·090	6·86	+ ·505	·02345	6·7	+3·71
G0 – G5	<0·050	6·80	+1·004	·00582	27·0	+0·62
	>0·050	6·53	+ ·973	·01636	9·6	+2·60
G6 – K5	<0·030	6·40	+1·465	·00345	45·5	−0·91
	>0·030	6·24	+1·396	·00893	17·6	+0·99

For each subdivision an equation was formed of the form

$$\text{Mean colour index} = a + b\bar{m} + c\bar{\mathrm{M}} + d\bar{\Delta}.$$

The constants a which depend upon the spectral type were eliminated by subtracting the two equations belonging to each type and the following five equations were obtained :—

$$\begin{aligned}
&\cdot 30b + 16\cdot 9d - 1\cdot 20c = +\cdot 083\\
&\cdot 49b + 14\cdot 1d - 1\cdot 38c = +\cdot 059\\
&\cdot 10b + 10\cdot 0d - 1\cdot 89c = -\cdot 006\\
&\cdot 27b + 17\cdot 4d - 1\cdot 98c = +\cdot 031\\
&\cdot 16b + 27\cdot 9d' - 1\cdot 90c = +\cdot 069
\end{aligned}$$

It is convenient to put $b = 10b'$, $10d = d'$, and then

	Residuals.
$d' + 1\cdot 78b' - 0\cdot 71c = +\cdot 049$	$-\cdot 010$
$d' + 3\cdot 48b' - 0\cdot 98c = +\cdot 042$	$+\cdot 002$
$d' + 1\cdot 00b' - 1\cdot 89c = -\cdot 006$	$-\cdot 001$
$d' + 1\cdot 55b' - 1\cdot 14c = +\cdot 018$	$+\cdot 004$
$d' + 0\cdot 59b' - 0\cdot 68c = +\cdot 025$	$+\cdot 004$

These equations were solved by the method of least squares, equal weight being given to each equation. The normal equations obtained are

$$\begin{aligned} 5d' + 8{\cdot}40b' - 5{\cdot}40c &= +{\cdot}128 \\ 8{\cdot}40d' + 19{\cdot}03b' - 8{\cdot}73c &= +{\cdot}270 \\ 5{\cdot}40d' + 8{\cdot}73b' - 6{\cdot}79c &= +{\cdot}103 , \end{aligned}$$

the solution of which gives

$$b' = +0{\cdot}0087,\ c = +0{\cdot}0336,\ d' = +0{\cdot}0473.$$

Upon substitution in the original equations the residuals shown above are obtained, and calculating the probable errors from these, the result obtained is

$$\begin{aligned} b &= +0^{m}{\cdot}087 \quad \pm 0{\cdot}121 \\ c &= +0^{m}{\cdot}0336 \pm 0{\cdot}0053 \\ d &= +0^{m}{\cdot}00473 \pm 0{\cdot}00035 \end{aligned}$$

These probable errors may be taken as indicating the agreement of the equations derived from the various spectral types *inter se*. Depending as these do upon widely differing distances, they tend to support the values obtained.

The value of b thus obtained is $+0^{m}{\cdot}087$. This is the increase in the difference between the photographic and visual magnitudes per unit increase in apparent magnitude. As such it indicates that the range of one magnitude is not the same in the photographic scale as it is in the photometric, the difference being 8·7 hundredths of a magnitude.

The derivation in this way of a control upon the mutual relations of the photometric and photographic magnitude scales is interesting. This method is not, however, suitable for determining this quantity with great accuracy, because it enters into the equations from which we started with small coefficients, so that any change in b produces a much smaller change in c and d. This is also shown by the large probable error found for b. It is also possible that b may vary with the spectral type: such a variation, if it exists, could only have been detected by splitting up each group of stars into three or more subdivisions. If there is such a variation, the value of b obtained above would represent a mean value. There are, however, indications that Parkhurst's magnitudes need a correction in the sense indicated; thus, by comparing his photographic magnitudes with those of Schwarzschild, the following mean results are found, Δ mag. being in the sense Parkhurst – Schwarzschild:—

Mean Mag.	Δ Mag.
6·50	+·02
7·35	+·05
7·78	+·07

If Schwarzschild's are assumed correct, Parkhurst's photographic

magnitudes for the fainter stars are relatively too large, which is also indicated by b having a positive value.

A comparison between Parkhurst's visual magnitudes and those of Müller and Kempf gives:—

Mean Mag.	Δ Mag. (P. – M. and K.).
5·47	+ ·06
6·30	– ·03
6·75	·00
7·11	– ·01
7·38	·00
7·63	·00

and, except for the brighter stars, the two scales are in good agreement.

If instead of deriving b in the above way, we were to assume *ab initio* that the range of one magnitude is the same in both the photographic and photometric scales, so that b becomes zero, and then re-solve our equations by least squares, the residuals obtained for the five equations would be, respectively,

$$-\cdot010,\ -\cdot013,\ +\cdot002,\ +\cdot005,\ +\cdot015$$

and the resulting values of d' and of c are

$$d' = +0^{m}\cdot0652 \pm \cdot0074$$
$$c = +0\ \cdot0367 \pm \cdot0086$$

The value of c remains practically unaltered, and the whole of the change in b has gone to produce a change in d', which is, however, not large enough to affect the order of magnitude of this quantity. The probable errors are somewhat increased.

Turning now to the quantity c, which gives the average increase in redness for a unit increase in the intrinsic magnitude. Whereas the b term was an effect resulting from the choice of magnitude scales, the effect dependent upon the c term is cosmical in its origin: it indicates that for stars of the same spectral type and at the same distance, the most luminous will on the average appear the bluer. The physical interpretation of this result is somewhat difficult to see, but it may possibly be explained as follows:—Each group of stars discussed contains stars which vary in intrinsic luminosity, and also in temperature. The range of variation in luminosity probably increases with the order of the spectral type: the temperature will decrease, on the average, more or less uniformly from type B to type K. In the mean, the brighter stars in any one group will be the hotter, and the wave-length corresponding to the maximum emission of energy will vary approximately inversely as the temperature (the variation would be accurately as T^{-1} if the stars radiated as black bodies). Therefore the intrinsically brighter stars will have their wave-length of maximum emission displaced towards the blue relatively to the fainter ones, and so will appear bluer. The effect is very small, an increase of the absolute magnitude by 1^{0m} only increasing the

colour index by $0^m{\cdot}33$: small as it is, however, its existence is definitely indicated by the equations, which cannot be satisfied at all by assuming c to be zero: thus, *e.g.*, if c is zero, and a solution is made to obtain b' and d', the values obtained are

$$d' = +{\cdot}007 \pm {\cdot}015$$
$$b' = +{\cdot}011 \pm {\cdot}029$$

The probable errors have been very much increased, and are now considerably larger than the quantities themselves.

The existence of this quantity c is important for the interpretation of the results of some of the methods for obtaining evidence as to the existence of an absorption of light in space. Thus, *e.g.*, Adams photographed the spectra of a number of stars of the same apparent magnitude, and same spectral type, but one of which had a small and the other a large proper motion. He found that in most cases the star of small proper motion was relatively faint in the violet and in no case was the reverse found. This can be explained by absorption, the stars of small proper motion being, on the average, at greater distances. But they will also be intrinsically brighter, and the result would also be accounted for if there were no absorption, if the bright stars appeared on the average redder than the faint. The positive value of c indicates that they appear, on the contrary, bluer, so that the effects found by Adams must be attributed to absorption.

Finally, we have to consider the evidence for absorption of light in space, as indicated by the present discussion. The value of d, *i.e.* the difference between the photographic and visual absorptions in a distance of 10 parsecs, is found to be

$$d = +0^m{\cdot}00473 \pm {\cdot}00035.$$

This value is smaller than that found by many other investigators, but agrees satisfactorily with Kapteyn's original determination by this method, which gave $+0{\cdot}0031 \pm 0{\cdot}0006$ (by assuming $c = 0$). A later result, based upon the Boss stars in the Parkhurst catalogue, published during the course of the present investigation, gave the value $+0{\cdot}0050 \pm 0{\cdot}0019$, which agrees very well with the value found in the present paper, although it is much smaller than many other determinations. The agreement between the two results is, however, partly illusory, owing to the fact that Kapteyn obtained his mean distances from the mean parallaxes of stars of given magnitude and proper motion as given in the Groningen tables, no account being taken of the spectral type, whereas the present result is based not only upon the Groningen tables, but also upon the mean parallactic motion of each group. For the purpose of comparison with Kapteyn's results, the equations were re-solved, using distances deduced simply from the parallax tables of Kapteyn, and the results obtained were—

$$b = +0{\cdot}086 \quad \pm 0{\cdot}131$$
$$c = +0{\cdot}0503 \pm 0{\cdot}0042$$
$$d = +0{\cdot}00716 \pm 0{\cdot}00029$$

The value of b is practically the same as before, as also its probable error. c and d are each increased by about one-half of their amounts, the probable errors not being much changed. Thus the material under discussion, if treated as by Kapteyn, gives a larger value than he obtained. The present result seems to be based upon a sounder method of calculation. The agreement between two quite independent determinations is, however, sufficiently good to indicate that the order of magnitude of the amount of absorption may be fixed with some degree of certainty: this is very small —the difference between the photographic and visual absorptions only amounting to 1 magnitude in a distance of about 2150 parsecs, or about 7000 light years. The results indicate how desirable it is to have accurate photographic and visual magnitudes for a large number of stars of well-determined proper motions and of known spectral type in order to obtain an accurate value of the absorption.

When accurate values of c and d have been obtained, and sufficient material accumulated to derive a value of a for each spectral type separately, a means will be provided for calculating the parallaxes of distant stars, when their type and their visual and photographic magnitudes are known. Since with the units adopted $\Delta = 1/10\pi$, it is only necessary to solve the equation

$$\text{Col. index} = a + bm + c(m - 5\log\Delta) + d\Delta$$

or

$$\Delta - \alpha\log\Delta = \beta,$$

in order to obtain Δ, and therefore π.

As an illustration of this method of determining the parallax of a distant star, consider the star Fed. 3638, whose parallax has been determined as $-0''{\cdot}015$. For this star Parkhurst finds a visual magnitude of 7·17 and colour index 0·120, and spectral type A3. The value of a for this type is not known, but a value can be determined by assuming that the mean values found for the groups B8 – A4 and A5 – F0 are the true values for a spectral type corresponding to the middle of the group, and then interpolating. In this way we find that $a + 6{\cdot}50b = -{\cdot}054$. This procedure is not strictly logical, and no great accuracy can be ascribed to the result, but it will illustrate the method. The equation obtained is

$$125 = 168\log\Delta - 4{\cdot}7\Delta.$$

This is very nearly satisfied if $\Delta = 19$ or 12, corresponding to parallaxes of $0''{\cdot}0053$ and $0''{\cdot}0083$ respectively, as compared with a measured parallax of $-0''{\cdot}015$. It is impossible to discriminate between the two values, but, as a general rule, the smaller is the more probable. The result indicates that the parallax is of the order of a few thousandths of a second.

As another example we may take the star Cephei 31, with a measured parallax of $-0''{\cdot}034$. Parkhurst gives visual magnitude

5·15 and colour index 0·28, type F5. Proceeding as before, the equation to be solved is

$$93 = 168 \log \Delta - 4{\cdot}7\Delta,$$

whence $\Delta = 36$ (approx.), the alternative value being rejected, because it corresponds to an easily measurable parallax. Therefore the parallax indicated is $0''{\cdot}0028$.

The determination of parallaxes by this method is liable to a fairly large probable error, which, however, is considerably smaller than the error to which an observational determination would be liable. An idea of the accuracy may be easily formed thus: We assume that a, b, c, d are correctly known. For a single star $\pi = 1/10\Delta$, and the colour index is

$$p = a + bm + c(m - 5 \log \Delta) + d\Delta.$$

An error δp in p causes an error $\delta\Delta$ in the deduced value of Δ where

$$\delta p = (d - 5c \log_{10} e/\Delta)d\Delta.$$

If $\delta p = \pm 0^{m}{\cdot}03$, and if $\Delta = 50$, then with the values of c and d above derived $\delta\Delta = \pm 10$. Now $\Delta = 50$ corresponds to a parallax of $0''{\cdot}0020$, whilst $\Delta = 60$, 40 correspond respectively to $\pi = 0''{\cdot}0017$, $\pi = 0''{\cdot}0025$. The possible error is largest for our values of c and d in the neighbourhood of $\Delta = 13$.

The loss of light due to scattering which has been determined above is the difference between the photographic and visual losses. If the assumption is made that the loss is caused entirely by a selective scattering obeying Rayleigh's law—which seems a justifiable assumption to make—then it is possible to determine the loss both for the photographic and for the visual rays. Parkhurst gives the spectral intensity curves of the photographic plates used in determining the photographic magnitudes, and also of the plates used in conjunction with a photo-visual filter in the determination of the visual magnitudes. From these can be obtained the relative amount of energy contributed by each wavelength in the two cases, and, assuming Rayleigh's law, the relative losses can be easily calculated from these figures. The result obtained is that the

Loss of visual brightness = ·411 × Loss of photographic brightness,

also in a distance of 10 parsecs we have

$$\text{Photographic loss} - \text{visual loss} = 0^{m}{\cdot}00473,$$

and, combining these results, it follows that in a distance of 10 parsecs, due to the scattering of light, there is a loss for photographic rays of 0·0080 magnitudes and a loss for visual rays of 0·0033 magnitudes.

Summary of Results.

The chief results obtained in the present paper may be summarised as follows:—

(*a*) The material used indicates that there is a small but appreciable loss of light in space due to selective scattering, the difference between the photographic and visual losses in a distance of 10 parsecs being $+0^{m}\cdot00473 \pm \cdot00035$. Assuming that the scattering is in accordance with Rayleigh's law, this is due to a loss for the photographic rays of $0^{m}\cdot0080$, and for the visual of $0^{m}\cdot0033$. The order of magnitude of this absorption agrees well with that found by Kapteyn.

(*b*) There is an effect of the absolute magnitude upon the colour index, the increase of colour index due to unit increase in absolute magnitude being $+0^{m}\cdot0336 \pm 0\cdot0053$. This means that, on the average, considering stars of the same spectral type and at the same distance, the more luminous ones appear to be bluer.

(*c*) When the values of c and d have been well determined, and when a is known for each spectral type separately, a means will be afforded of deriving the parallaxes of distant stars much more accurately than is possible by observation.

Royal Observatory, Greenwich.

Mean Areas and Heliographic Latitudes of Sun-spots in the Year 1913.

(*Communicated by the Astronomer Royal.*)

The results here given are in continuation of those printed in the *Monthly Notices*, vol. lxxiii. p. 688, and are deduced from the measurements of photographs taken at the Royal Observatories of Greenwich and of the Cape, and in India at the Kodaikánal Observatory and at Dehra Dûn, North-West Provinces.

Table I. gives the mean daily area of umbræ, whole spots, and faculæ for each synodic rotation of the Sun in the year 1913, and Table II. gives the same particulars for each of the entire years 1901 to 1913 inclusive. The areas are given in two forms: first, projected areas, that is to say, as seen and measured on the photographs, these being expressed in millionths of the Sun's apparent disc; and next, areas as corrected for foreshortening, the areas in this case being expressed in millionths of the Sun's visible hemisphere.

Table III. exhibits for each rotation in the year 1913 the mean daily area of the whole spots (corrected for foreshortening),

and the mean heliographic latitude of the spotted areas for spots north and for spots south of the equator, together with the mean heliographic latitude of the entire spotted area, and the mean distance from the equator of all spots; and Table IV. gives the same information for each year as a whole for the years 1901 to 1913 inclusive. Tables II. and IV. are thus in continuation of the similar tables for the years 1874 to 1888 on pp. 381 and 382 of vol. xlix. of the *Monthly Notices*, and for the years 1889 to 1902 on pp. 465 and 466 of vol. lxiii., and for the years 1901 to 1912 on pp. 689 and 690 of vol. lxxiii.

The rotations in Table I. and Table III. are numbered in continuation of Carrington's series (*Observations of Solar Spots made at Redhill*, by R. C. Carrington, F.R.S.), No. 1 being the rotation commencing 1853 November 9. The assumed prime meridian is that which passed through the ascending node at mean noon of 1854 January 1, and the assumed period of the Sun's sidereal rotation is 25·38 days. The dates of the commencement of the rotations are given in Greenwich civil time, reckoning from mean midnight.

TABLE I.

No. of Rotation.	Date of Commencement of each Rotation.		No. of Days on which Photographs were taken.	Mean of Daily Areas.					
				Projected.			Corrected for Foreshortening.		
				Umbræ.	Whole Spots.	Faculæ.	Umbræ.	Whole Spots.	Faculæ.
	1913.	d							
793	Jan.	1·97	27	2	15	182	2	14	192
794	Jan.	29·31	28	6	29	142	4	21	148
795	Feb.	25·65	27	1	3	140	1	3	142
796	Mar.	24·97	27	1	6	77	1	4	84
797	Apr.	21·24	27	0	0	42	0	0	47
798	May	18·48	28	0	0	62	0	0	62
799	June	14·68	27	2	7	51	1	4	52
800	July	11·88	27	1	6	81	1	3	91
801	Aug.	8·09	27	0	0	13	0	0	18
802	Sept.	4·33	28	1	5	59	1	4	66
803	Oct.	1·61	27	5	16	60	3	12	73
804	Oct.	28·90	27	1	11	58	1	7	69
805	Nov.	25·21	28	6	28	160	3	19	184

TABLE II.

Year.	No. of Days on which Photographs were taken.	Mean of Daily Areas. Projected. Umbræ.	Whole Spots.	Faculæ.	Corrected for Foreshortening. Umbræ.	Whole Spots.	Faculæ.
1901	359	14	41	23	9	29	29
1902	349	14	86	163	10	62	178
1903	350	67	434	875	51	340	970
1904	363	93	653	1639	67	488	1761
1905	364	230	1637	2433	163	1191	2612
1906	364	158	1047	2207	114	778	2320
1907	365	221	1453	1859	160	1082	1999
1908	366	148	952	2000	106	697	2098
1909	364	171	941	1303	124	692	1353
1910	365	67	357	984	49	264	971
1911	364	16	88	458	12	64	459
1912	365	10	50	201	7	37	210
1913	365	2	10	87	1	7	95

TABLE III.

No. of Rotation.	Date of Commencement of each Rotation.	No. of Days on which Photographs were taken.	Spots North of the Equator. Mean of Daily Areas.	Mean Heliographic Latitude.	Spots South of the Equator. Mean of Daily Areas.	Mean Heliographic Latitude.	Mean Heliographic Latitude of entire Spotted Area.	Mean Distance from Equator of all Spots.
	1913. d			°		°	°	°
793	Jan. 1·97	27	7·0	23·93	7·4	13·31	+ 4·83	18·48
794	Jan. 29·31	28	21·2	31·47	0	...	+31·47	31·47
795	Feb. 25·65	27	2·1	30·89	0·9	35·20	+10·74	32·20
796	Mar. 24·97	27	0	...	3·6	1·96	− 1·96	1·96
797	Apr. 21·24	27	0	...	0	..	...	...
798	May 18·48	28	0	...	0	...	...	..
799	June 14·68	27	4·3	28·58	0	...	+28·58	28·58
800	July 11·88	27	3·4	28·64	0	...	+28·64	28·64
801	Aug. 8·09	27	0	...	0	...	...	...
802	Sept. 4·33	28	3·9	4·63	0	...	+ 4·63	4·63
803	Oct. 1·61	27	12·4	19·56	0	...	+19·56	19·56
804	Oct. 28·90	27	4·6	18·34	2·2	27·60	+ 3·44	21·35
805	Nov. 25·21	28	0	...	18·8	24·46	−24·46	24·46

TABLE IV.

Year.	No. of Days on which Photographs were taken.	Spots North of the Equator.		Spots South of the Equator.		Mean Heliographic Latitude of entire Spotted Area.	Mean Distance from Equator of all Spots.
		Mean of Daily Areas.	Mean Heliographic Latitude.	Mean of Daily Areas.	Mean Heliographic Latitude.		
1901	359	22	8°·59	7	16°·27	+ 2°·82	10°·37
1902	349	42	18·81	21	15·29	+ 7·48	17·64
1903	350	132	18·11	208	21·15	− 5·85	19·94
1904	363	268	16·33	220	16·88	+ 1·37	16·57
1905	364	750	11·66	440	15·55	+ 1·60	13·10
1906	364	539	13·98	239	14·01	+ 5·38	13·99
1907	365	488	10·12	593	13·77	− 2·98	12·12
1908	366	316	10·42	381	10·34	− 0·92	10·38
1909	364	299	9·45	393	9·92	− 1·55	9·71
1910	365	66	8·55	198	11·18	− 6·27	10·53
1911	364	17	7·89	47	5·99	− 2·30	6·49
1912	365	1	20·53	36	7·78	− 7·18	8·06
1913	365	5·0	24·81	2·5	20·08	+ 9·81	23·23
1913, Old Cycle	365	0·3	4·63	0·4	4·27	− 0·33	4·43
,, New Cycle	365	4·7	26·09	2·1	22·87	+10·81	25·08

The principal features of the record for 1913 are:—

1. The continuance of the rapid decline in the mean daily spotted area that began in 1910 almost to the point of a complete absence of spots. Wolf's "Relative Numbers," as revised by Wolfer, show that no year since 1810 has been so barren of sun-spots as 1913.

2. The results for the separate rotations in 1913 show that the few spots observed were confined almost entirely to the beginning and end of the year; for seven months the Sun was nearly always free from spots.

3. The areas of the faculæ have, as usual, varied much less than those of the spots, and the falling off from 1912 has been less marked; the figure for 1913 being 45 per cent. of that for 1912 in the case of the faculæ, but only 20 per cent. with the spots. While the mean daily area for the spots of 1913 was lower than in any other year for a century past, that for the faculæ, though lower than for the minimum year 1889, was not so low as in 1878 or 1901. The minimum for spots clearly fell in the middle of 1913; that for faculæ may prove to have followed it by a few months.

4. Comparing the two hemispheres, the predominance in spotted area, which had lain with the southern hemisphere from

early in 1907, passed to the northern; the latter being free from spots during five rotations, while the former remained quiescent during eight. In both hemispheres the majority of the groups were in high latitudes, indicative of the new period of activity; but two short-lived groups appeared in the equatorial zone, one on each side of the equator, and may therefore be regarded as the last members of the expiring cycle.

5. The mean distance from the equator of all spots was the highest (23°·23) since the minimum of 1901, so that the new cycle has definitely commenced. If the groups belonging to the old and new cycles are separated, the mean latitudes shown at the foot of Table IV. will be obtained.

6. The Sun was free from spots on 311 days in 1913, as compared with 246 in 1912, and 183 in 1911.

7. The number of separate groups observed in 1913 was 15, or 38 per cent. of that for 1912; a smaller decline than that in area, so that the proportion of small and short-lived spots was still on the increase.

8. Of the 15 separate groups of the year, the majority, 9, were in the northern, against only 6 in the southern hemisphere—a further indication that a new cycle has commenced.

Royal Observatory, Greenwich,
1914 *November* 9.

Note on the Nebular Line λ3729. By W. H. Wright.

(*Communicated by the Secretaries.*)

In the *Monthly Notices* for May of this year Dr. J. W. Nicholson contributes a paper on the origin of the nebular line at λ3729. This paper forms one of a series of most interesting communications by this investigator which has attracted such very general attention that detailed references to the individual papers are not for the moment necessary.

In these papers Dr. Nicholson has discussed certain hypothetical molecular models—systems made up of charged nuclei surrounded by rings of electrons—and has with great skill developed certain possible points of correspondence between the vibrations of these systems and the spectra of various celestial bodies, chiefly the nebulæ and the Wolf-Rayet stars.

I am not sure that a careful consideration of the evidence presented by these objects lends strength to all of Dr. Nicholson's deductions. For a number of years I have devoted a small part of my observing time to a study of nebular spectra, and the result of this work will soon be published, and may perhaps serve as a basis for a further discussion of this subject. For the present I wish only to call attention to what appears to be a misinterpretation of a photograph of the Orion nebula secured with a prismatic

camera by Mr. J. H. Reynolds at Helwân. This photograph was exhibited at the meeting of the Royal Astronomical Society of April 8th, and is referred to in the account of that meeting published in the *Observatory* magazine for May, p. 199. A list of the wave-lengths corresponding to the several images of the nebula is given in this publication, the last wave-length being "3729." This is, of course, only an approximate value, since the diameter of the brightest part of the nebula is of the order of 100 A. The image is unquestionably due to the combined rays λ3726·4 and λ3729·0, both of which are present in the Orion nebula. Of these two lines, which have generally been observed as a single line, the first is the brighter, and has been ascribed by Dr. Nicholson to nebulium. It is without doubt chiefly responsible for the so-called λ3729 image.

The doublet (λλ3726–29) exists in numerous nebulæ, and the components always appear to have, as nearly as one can tell from inspection of the plates, the same relative intensities, though other lines in these nebulæ vary greatly in this respect. It is to be supposed, therefore, in the absence of reliable evidence to the contrary, that the components maintain their relative intensities throughout the Orion nebula, as well as in the bright parts where they have usually been observed, and that the whole of the image at 373μ is due chiefly to the line at λ3726·4 which Dr. Nicholson has ascribed to nebulium. It therefore seems that the statement in the paper referred to at the beginning of this note to the effect that ". . . Mr. Reynolds' observations complete the practical demonstration that λ3729 has a different chemical origin from other lines such as λ5007 . . ." requires modification at least to the extent of including λ3726·4 with λ3729. This would, of course, violate the theory of the common origin of 3726·4 and 5007, unless the different forms of nebulium discussed by Dr. Nicholson are understood to be chemically different.

As stated in the foregoing remarks, wherever the lines λλ3726–29 occur, they appear to have the same relative intensities. Sometimes the record is so faint that only the first line appears, but in every case where that is sufficiently strong the fainter line is present. The constancy of this intensity ratio in the presence of the enormous variations which occur in the relative strengths of many other lines is strongly suggestive of a common origin of both.

Lick Observatory,
Mt. Hamilton, California.

[*Note by Dr. Nicholson.*—I admit that Dr. Wright's criticism is justified. For some time I have known that the origin of the line λ3726·5 suggested in my original paper * on nebulium could not be correct. In my second paper, a correction, to which my attention was called by Dr. Bromwich, was made to the lower wave-length of any pair, which was always 2 or 3 tenth-metres in error in the original paper. The application of this correction, although

* *M.N.*, vol. lxxii. p. 63, 1911.

strengthening the evidence for the theory in most cases, did in fact prove that the identification of λ3726·5 was incorrect, for in this case (and in one other) the error became larger instead of disappearing. The results of the correction have only been published in connection with the coronal spectrum. Perhaps I should have mentioned them at the time for the nebular spectrum also.

That the components of the doublet at λ3729 have a common origin is also proved by the work of Bourget, Buisson, and Fabry. I hope to give a tabulated scheme of suggested origins of nebular lines very shortly.—J. W. N.]

Observations made during the Partial Eclipse of the Sun on 1914 August 20–21 at the University Observatory, Warsaw. By Professor S. Tscherny.

(*Communicated by the Secretaries.*)

Phenomenon.	Telescope.	Warsaw Mean Time. h m s	Observer.	Remarks.
First contact . . .	M I.	0 44 11·6	S. T.	
,, ,, . . .	M II.	0 44 7·0	M. S.	
,, ,, . . .	E.	0 44 17·8	S. J.	Retardation.
,, ,, . . .	L. S.	0 44 5·0	G. To.	
,, ,, . . .	M III.	0 43 51·0	S. S.	Uncertain.
First contact of the Moon and the penumbra of the large sun-spot	M I.	1 3 55·6	S. T.	
	M II.	1 4 0·7	M. S.	
First contact of the Moon and the umbra of the large sun-spot	M I.	1 4 42·6	S. T.	
	M II.	1 4 41·6	M. S.	
	M III.	1 5 17·7	S. S.	
	L. S.	1 4 45·0	G. To.	
Second contact of the Moon and the umbra	M I.	1 5 38·6	S. T.	
	L. S.	1 5 29·0	G. To.	
Third contact of the Moon and the umbra	L. S.	2 16 50·0	G. To.	
Fourth contact of the Moon and the umbra	M I.	2 18 27·7	S. T.	
	M III.	2 18 25·4	S. S.	
	L. S.	2 18 32·0	G. To.	
Fourth contact of the Moon and the penumbra	M I.	2 19 6·7	S. T.	
	M III.	2 18 58·3	S. S.	Uncertain.
Last contact . . .	M I.	3 6 16·7	S. T.	
,, ,, . . .	M II.	3 6 10·1	M. S.	Projection method employed.
,, ,, . . .	M III.	3 6 17·0	S. S.	
,, ,, . . .	E.	3 6 14·4	S. J.	
,, ,, . . .	L. S.	3 5 59·0	G. T.	

Instruments used :—

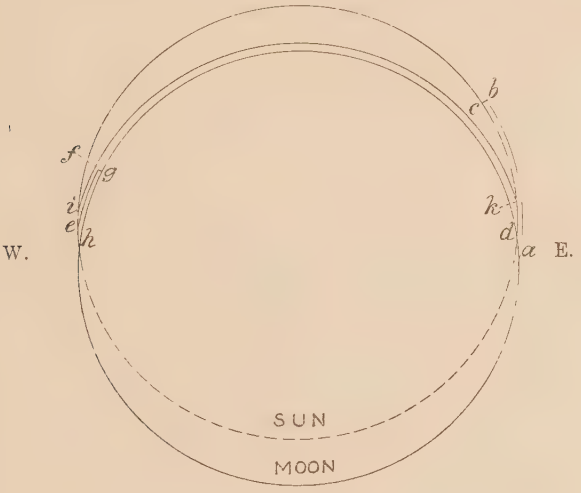
M I.	162 mm. Merz refractor, stopped to 102 mm.	Power 200.
M II.	102 mm. Merz-Sabler refractor	,, 93.
M III.	75 mm. Merz refractor	,, 58.
L. S.	102 mm. Lerebours et Secrétan refractor .	,, 60.
E.	47 mm. Ertel und Sohn vertical circle . .	,, 52.

Observers :—

S.T.	S. Tscherny.	G.To.	G. Tolwinski.
M.S.	M. Subbotin.	S.S.	S. Swiderski.
S.J.	S. Jasenski.		

The magnitude of the eclipse at Warsaw was 0·92.

The lunar mountains were seen projected on the solar disc. The colour (reddish) of the umbra of the sun-spot seemed to be decidedly lighter in tone than the black Moon. A few minutes before and after maximum revealed a great decrease of light as one had opportunity to glance at the landscape; a feeble, watery light, such as we see sometimes in the morning when we look at



a, *b*, *c*, *d*, the chromosphere. *e*, *f*, *g*, *h*, the red layer.
h, *i*, *k*, *d*, the yellow aureola.

the Sun through much vapour. *Venus* was noticeable at the maximum, but not *Mercury* or any stars. Professor S. Tscherny observed the chromosphere near the eastern horn of the Sun from $1^h\ 59^m$ to $2^h\ 10^m$. At the same time, near the western horn of the Moon, a red layer was observed, and the visible border of the Moon was surrounded by a yellow aureola (see sketch).

The following meteorological observations were made by M. Subbotin and S. Jasenski:—

Warsaw Mean Time.	Barom. 0° C.	Humidity. Absol.	Humidity. Relat.	Clouds.	Wind.	Temperature C.
h m	mm.				m/sec.	°
0 17	755·91	37	6·1	Cu, 0	E. 1·6	+19·4
0 27	...	31	5·1	Cu, 0	E. 1·6	19·2
0 37	...	34	5·7	Cu, 0	E. 1·6	19·5
0 47	...	35	6·1	Cu, 0	E. 1·6	19·9
1 0	755·73	28	4·8	Cu, 0	S.W. 1·7	19·8
1 7	755·62	36	6·1	Cu, 0	N.N.E. 1·4	19·6
1 17	755·63	35	5·8	Cu, 0	E. 1·5	19·4
1 27	...	39	6·3	Cu, A-Cu, 0	...	19·2
1 37	755·54	40	6·3	Cu, A-Cu, 0	N.N.E. 1·0	18·4
1 47	755·45	38	5·9	Cu, A-Cu, 0	E.N.E. 1·0	17·9
1 57	...	45	6·4	Cu, A-Cu, 0	0·0	16·8
2 7	755·42	50	6·8	Cu, A-Cu, 0	E.S.E. 0·6	16·0
2 17	755·48	53	7·4	Cu, 0	E.S.E. 0·3	16·4
2 27	...	37	5·7	0	E.S.E. 0·3	17·8
2 37	755·47	37	6·0	0	S.E. 0·1	18·6
2 47	755·45	37	6·0	0	S.S.W. 0·1	18·8
2 57	..	32	5·2	0	S.S.W. 0·1	18·8
3 7	755·52	38	6·4	0	S.W. 0·2	19·6
3 17	...	31	5·3	0	E.N.E. 0·9	19·8
3 27	...	34	5·9	0	E.S.E. 0·9	19·9
3 37	...	32	5·5	Cu, 1	S.S.W. 0·9	19·8
3 47	...	33	5·7	Cu, 2	S.S.W. 0·9	19·9
3 57	...	33	5·6	Cu, 2	S.S.W. 0·9	19·8
4 12	755·09	34	5·7	Cu, 2	E.S.E. 0·8	19·8

1914 *August* 25.

The Partial Eclipse of the Sun, 1914 *August* 20–21, *observed at South Kensington.* By A. Fowler, F.R.S.

Observations of the partial eclipse (mag. 0·65) were made at the Imperial College, South Kensington (lat. 51° 29′ 50″ N., long. 42·4s W.), but the conditions were not very favourable in consequence of considerable haze, especially about the beginning of the eclipse. Observations of the contacts were made by the spectroscopic method, using the Evershed spectroscope on the 6-inch equatorial. The results were as follows:—

First contact, G.M.T. $22^h\ 58^m\ 19^s$
Last contact, $1\ 20\ 22$

The time given for first contact may be incorrect by as much as 2 or 3 seconds, but that for last contact is believed to be not more than 1 or 2 seconds in error. An interpolation based upon the data given in the *Nautical Almanac* for Greenwich, Oxford, and Cambridge indicates that the first contact occurred about 39 seconds, and the last about 37 seconds, in advance of the calculated times.

The magnitude of the eclipse was not great enough to permit such extensive observations of the chromospheric lines at the cusps as were made in 1912,* but for about 10 minutes near the time of maximum phase several of the high-level lines were easily observed.

Partial Eclipse of the Sun, 1914 *August* 20–21, *observed at the Radcliffe Observatory, Oxford.* By Arthur A. Rambaut, D.Sc., F.R.S., Radcliffe Observer.

The following observations of the partial eclipse of the Sun on August 20–21 were made at the Radcliffe Observatory:—

First Contact:

G.M.T.	Obsr.	
$22^h\ 57^m\ 14^s{\cdot}4$	W.	Moon's limb first seen at this time.
22 57 7·2	H.B.	First contact. Good.

Last Contact:

1 18 34·9	W.	Good.
1 18 35·5	H.B.	Satisfactory.

The computed times of the beginning and ending of the eclipse, as given in the *Nautical Almanac*, are $22^h\ 57^m{\cdot}6$ and $1^h\ 19^m{\cdot}1$ G.M.T. respectively.

At the time a large spot was conspicuous on the solar disc. The time at which this disappeared behind the Moon's limb was also observed as follows:—

Sun-spot:

23 21 37·4	W.	Contact of Moon's limb with umbra of spot.
23 22 17·4	,,	Contact with white filament bridge in spot.
23 23 6·4	,,	Last contact with umbra of spot.

Note.—The Moon's limb was fairly steady on the solar disc, showing some rugged eminences in profile (W.). W. (= Mr. Wickham) observed with the Marlborough telescope of $3\frac{1}{4}$ inches aperture, power 54; H.B. (= Mr. Barrett) with the Barclay equatorial of 10-inches aperture, power 90.

* *Monthly Notices*, vol. lxxii. p. 538.

Partial Eclipse of the Sun, 1914 August 20–21, observed at Armagh. By J. L. E. Dreyer, Ph.D.

With the 10-inch refractor and a power of 100 the contacts were observed as follows:—

Beginning,	$22^h\ 48^m\ 54^s.8$	Greenwich M.T.
End,	$1\ 8\ 17^s.4$	

The first contact was observed through thin flying clouds. At the last contact the sky was clear and the definition good. The predicted moments in the *Nautical Almanac* were $0^m.6$ later.

Armagh Observatory:
1914 *Sept.* 22

Observations of Delavan's Comet (1913 f), obtained at its Lower Meridian Passage with the Transit Circle at the Royal Observatory, Greenwich.

(*Communicated by the Astronomer Royal.*)

Date and G.M.T.	Appt. R.A.	Appt. N.P.D.	Assumed log Δ.
d h m s	h m s	° ′ ″	
1914 Sept. 24 10 58 49	11 10 31·05	−42 15 16·24	0·2044
25 11 2 21	11 18 0·51	−42 38 14·82	0·2031
29 11 15 42	11 47 9·57	−44 27 14·42	0·1993

The observations were made by Mr. Witchell on September 24 and 29, and Mr. Acton on September 25. They are corrected for parallax, the assumed values of log Δ being taken from F. E. Seagrave's elements. Those of Lick Observatory Bulletin 261 are 0·0004 greater in each case, the effect on the parallax being inappreciable.

Subtracting $13^m\ 19^s$, $13^m\ 16^s$, and $13^m\ 10^s$ from the above mean times, for light passage, tabular places were computed with second differences from the Ephemeris in Lick Bulletin 261. The comparison indicated the following corrections to the Ephemeris:—

Date.	Correction to Ephemeris in R.A.	Correction to Ephemeris in N.P.D.
	s	′ ″
Sept. 24	+8·36	+1 46·69
25	+7·68	+1 49·17
29	+8·27	+2 3·19

Royal Observatory, Greenwich:
1914 *Nov.* 10.

ROYAL OBSERVATORY, GREENWICH.

Comet 1913 *f* (Delavan). 1914 Sept. 20. $15^h\ 46^m$ G.M.T. Exposure 45 min. $3\frac{1}{4}$-inch Portrait Lens. Scale 14 mm. = 1°.

ROYAL OBSERVATORY, GREENWICH

Comet 1913 (Delavan). 1914 Sept. 26. $16^h\ 20^m$ G.M.T. Exposure 25 min.
30-inch Reflector. Scale 20 mm.=10′.

Note on Photographs of Delavan's Comet. By P. J. Melotte. (Plates 1, 2.)

(*Communicated by the Astronomer Royal.*)

Photographs of the comet were obtained with the 30-inch Reflector and with a Portrait Lens of $3\frac{1}{4}$ inches aperture and 11 inches focal length on September 14, 20, 26 and 30, 1914.

The general appearance of the comet, as shown on the photographs, remains the same, and no very marked changes, like those undergone by Morehouse's comet, are recorded.

It is of interest, however, that two distinct types of tail, more often associated with different comets, are shown together. The photographs show the comet to have a bright nucleus of about the 6th magnitude. From this extends a long straight tail which can be traced, on the plate taken with the Portrait Lens on September 26, for a distance of nearly ten degrees. This tail appears to stream out immediately behind the nucleus (*i.e.* away from the Sun), and shows some irregularities or breaks. Another shorter and broader tail, which is curved in a marked degree, extends to a distance of four or five degrees from the nucleus. Near the head of the comet the axes of the two tails are inclined to one another at an angle of about 12°. The broad tail, which envelops the other up to a distance of nearly half a degree from the nucleus, is more sharply defined on the eastern side, and shows clearly the parabolic form of the envelopes. Visually the shorter tail appeared the brighter, whereas on the photographs the reverse is the case.

Whilst the longer, straight tail resembles, to a certain extent, the tail shown on some of the photographs of Morehouse's comet, the short curved one is not unlike that of Comet *a*, 1910.

Thanks are due to the Astronomer Royal for kindly giving permission to reproduce two of the photographs taken on September 20 and 26.

Observations of the Transit of Mercury, 1914 *November* 6–7, *made at the Royal Observatory, Greenwich.* (Plate 3.)

(*Communicated by the Astronomer Royal.*)

Observations of Contacts.

The different phases of the transit were observed under good conditions at Greenwich. None of the observers saw the "black drop," a halo round Mercury, or a bright spot on the planet. The phenomenon appeared just as might have been expected from geometrical considerations. A sharp black spot was seen to cross the Sun's disc. Owing to haze the brightness of the Sun was considerably diminished, so that the observing conditions were very favourable. There are the usual discrepancies, amounting to some

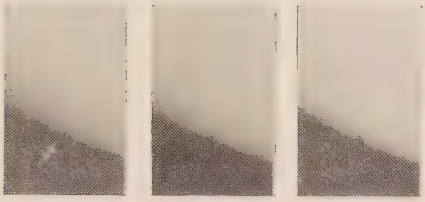
ten seconds, in the times of the contacts given by different observers. It may be noted in particular that the times of phase III. given by the observers using the 28-inch and the Merz refractors differ by ten seconds, although each considered he could not be above a second or two in error; while the observer with the astrographic guiding telescope gave his result as the mean of two observations, six seconds apart, between which he considered geometrical contact must have occurred. The difference in the first of these cases must be due to different observers forming different ideas of the meaning of geometrical contact, and in the second case to the admitted difficulty of accurately realising the idea of contact. The interest of these observations is their accord with the historic difficulties found in the case of the transit of Venus.

No observations of any value were made of the first contact, although most of the observers noted when the planet was first seen. Little confidence can be placed on the observations of phase IV., and all the observers gave the interval between phases III. and IV. too small by ten seconds or more; this is more probably due to the fourth contact having been observed early than to the third having been observed late, although both causes may have contributed.

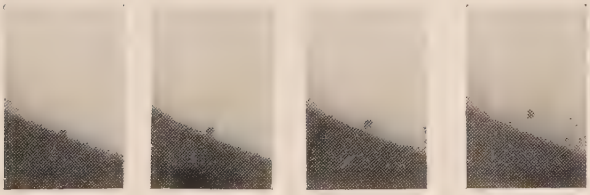
The initials D., H., A. C., C. D., H. F., W., P. M., J., refer to Mr. Dyson, Mr. Hollis, Mr. Crommelin, Mr. Davidson, Mr. Furner, Mr. Witchell, Mr. Melotte, and Mr. Jonckheere respectively.

Phase.	Telescope.	Aperture used. in.	Power.	G.M.T. d h m s	Observer.	Rema
II.	Astrographic	10	135	Nov. 6 21 59 53·8	H.	
II.	Sheepshanks	6·7	300	,, 43·3	A.C.	
II.	Merz	9	190	,, 53·7	C.D.	
II.	Corbett	6·5	150	,, 44·8	H.F.	
II.	Detached telescope No. 2	4	200	,, 43·0	P.M.	
II.	28-inch equatorial	20	210	,, 44·6	J.	(*a*
III.	Merz	9	190	Nov. 7 2 6 38·9	D.	
III.	Astrographic	8	135	,, 34·1	H.	(*b*
III.	Sheepshanks	6·7	300	,, 29·2	A.C.	
III.	Corbett	6·5	150	,, 29·9	H.F.	
III.	Detached 4-inch	4	75	,, 31·3	W.	
III.	28-inch equatorial	15	210	,, 28·4	J.	
IV.	Merz	9	190	Nov. 7 2 8 37·6	D.	
IV.	Astrographic	8	135	,, 35·8	H.	(*b*
IV.	Sheepshanks	6·7	300	,, 31·9	A.C.	
IV.	Corbett	6·5	150	,, 36·4	H.F.	
IV.	Detached 4-inch	4	75	,, 37·0	W.	
IV.	28-inch equatorial	15	210	,, 35·9	J.	

(*a*) Wire gauze screen used.
(*b*) Perhaps early.



G.M.T. $9^h\ 58^m\ 17^s$ $9^h\ 58^m\ 47^s$ $9^h\ 59^m\ 17^s$



$9^h\ 59^m\ 47^s$ $10^h\ 0^m\ 17^s$ $10^h\ 1^m\ 17^s$ $10^h\ 4^m\ 17^s$

TRANSIT OF MERCURY, 1914 NOV. 7, ROYAL OBSERVATORY, GREENWICH

From a general consideration of these results we obtain the following times for phases II. and III. with an error possibly amounting to 3 or 4 seconds:—

II.	Nov. 6^d	21^h	59^m	48^s
III.	Nov. 7	2	6	32

The times given in the *N.A.*, corrected for parallax, are

II.	Nov. 6^d	22^h	0^m	21^s
III.	Nov. 7	2	6	43

so that the contacts took place 33^s and 11^s before the predicted times.

From these results we can find corrections to the tabular place of Mercury, relative to the Sun. If the corrections are $\Delta\alpha''$ and $\Delta\delta''$ in right ascension and declination, we get the following equations:—

$$5{\cdot}1\Delta\alpha'' - 12{\cdot}5\Delta\delta'' = -33$$
$$12{\cdot}5\Delta\alpha'' + 3{\cdot}6\Delta\delta'' = -11$$

giving

$$\Delta\alpha = -1''{\cdot}5 = -0^s{\cdot}10, \quad \Delta\delta = +2''{\cdot}0.$$

These results are possibly in error to the extent of $0''{\cdot}3$.

Photographic Observations.

With the photoheliograph seven good plates were obtained near the beginning of the transit and four others during the transit; but the plates exposed near the end of the transit were spoiled by clouds. The first plate, taken at $21^h\ 57^m\ 17^s$, did not show the planet, but the second did. An examination of the plates led to the following results. In deducing the time of second contact from the times of the exposures, the motion given in the *N.A.* was used.

Plate.	Time of Exposure.			Deduced Time of Second Contact.			Position Angle of Mercury.		Correction to Predicted Value.
	h	m	s	h	m	s	°	′	′
2	21	58	17	21	59	58	156	18	− 8
3	21	58	47	21	59	54		30	− 3
4	21	59	17	21	59	52		30	− 9
5	21	59	47	21	59	58		36	−10
6	22	0	17	22	0	0		42	−11
7	22	1	17	21	59	50	156	54	−12
8	22	4	17	21	59	39	157	30	−16

There was considerable uncertainty in the measures from which the time of contact was deduced, but on the whole they indicate that the adopted value of the time of second contact was

too early. The position angles were obtained as the mean of the position angles of the limbs or cusps. The difference between the observed and predicted values of the position angles leads to the equation

$$10 = 1{\cdot}9\Delta\alpha'' + 4{\cdot}2\Delta\delta'',$$

which partially confirms the values for $\Delta\alpha$, $\Delta\delta$ found by other methods.

The annexed plate is reproduced from the seven photographs used in the above discussion.

Transit-Circle Observations.

The transits of the Sun and planet across the meridian were observed by Mr. Witchell, while Mr. Acton read the microscopes. Both limbs of both bodies were observed over all ten wires of the transit-circle, while two observations of the north polar distance of each limb of each body were secured. The results obtained were as follows:—

	R.A.			N.P.D.		
	h	m	s	°	′	″
Mercury	14	46	51·74	106	17	18·35
Sun	14	47	3·54	106	7	1·06

These indicate the following corrections to N.A.

R.A. of Mercury	$+0^{s}{\cdot}01$	N.P.D. of Mercury	$-2''{\cdot}25$
R.A. of Sun	$+0\cdot06$	N.P.D. of Sun	$-0\cdot54$

or the corrections to the right ascensions and declinations of the planet relative to the Sun are

$$\Delta\alpha = -0^{s}{\cdot}05 = -0''{\cdot}75, \quad \Delta\delta = +1''{\cdot}71.$$

These results agree very well with the results obtained from the contacts. In fact, the observations made within two and a half minutes with the transit-circle probably give as good a determination of the position of Mercury as the combination of all the observations made with other instruments.

Royal Observatory, Greenwich:
1914 *November* 12.

Measures of the Diameter of Mercury obtained at the Royal Observatory, Greenwich, during the Transit of 1914 *November* 6–7. By R. Jonckheere.

(*Communicated by the Astronomer Royal.*)

At the transit of Mercury in 1907, I made a series of measures with a 9-inch refractor at Roubaix.* The Observatory of the University of Lille was at the time being built. On the present occasion the Astronomer Royal kindly permitted me to use the 28-inch refractor.

All the following observations were obtained with the 28-inch refractor and the double star filar micrometer. 368 measures were taken by five observers, viz.:—

H.J. Mr. Jones.	H.F. Mr. Furner.
L. Mr. Lewis.	J. Mr. Jonckheere.
B. Mr. Bryant.	

To vary the conditions of observations four devices were used:—

1. The objective was stopped down to 20 inches and was veiled by a double wire gauze screen. Power 210. This made the disc of the planet whitish and diminished the effect of contrast.

2. The objective was stopped down to 20 inches, but with one single screen. Power 210. This made the planet a little darker, the screen still allowing the use of the large apparatus.

3. The objective was stopped to 15 inches and the wire gauze removed. Power 210. The planet appeared then quite black on the solar disc.

4. The same conditions but with larger power of 470 and a different dark glass.

All the observers agree that the phenomena from beginning to end occurred in a perfectly geometrical form; there was not the slightest indication of a "black drop," "bridge," "white spot," or halo.

A careful search was made for a possible satellite, both near and at a considerable distance from the planet, but nothing was detected.

For the small altitude of the object, the image was remarkably steady during all the transit. At $22^h\ 50^m$ Mr. Bryant observed that the horizontal diameter of the planet looked the smaller. At $0^h\ 5^m$ Mr. Furner was of the opinion that the vertical diameter appeared the larger and I had personally the same impression. This may be an optical illusion.

The micrometrical measures give the following results at various position angles:—

* *Monthly Notices*, vol. lxviii. p. 131.

20-inch Stop, Double Wire Gauze Screen, Power 210.

	Observer: H.F.			*Observer:* J.		
Angle.	Diam.	Obs.	Time.	Diam.	Obs.	Time.
			h m			h m
° 45	″ 9·78	6	22 25	″ 9·77	6	22 5
90	9·58	6	22 30	9·06	6	22 10
135	10·13	6	22 35	9·62	6	22 15
180	9·84	6	22 40	9·08	6	22 20

20-inch Stop, Single Wire Gauze Screen, Power 210.

	Observer: H.J.			*Observer:* B.		
Angle.	Diam.	Obs.	Time.	Diam.	Obs.	Time.
			h m			h m
° 45	″ 9·53	6	22 55	″ 9·58	7	23 36
90	9·00	7	23 0	9·25	6	23 38
135	9·68	6	22 52	9·59	6	23 34
180	9·30	8	23 7	9·53	8	23 40

	Observer: H.F.			*Observer:* J.		
			h m			h m
° 45	″ 9·82	6	23 21	″ 9·56	6	22 45
90	9·26	6	23 15	9·67	6	22 43
135	9·93	6	23 24	9·47	6	22 47
180	9·94	6	23 14	9·06	8	22 42

15-inch Stop, without Screen, Power 210.

Observer: H.F.

Angle.	Diam.	Obs.	Time.	Diam.	Obs.	Time.
			h m			h m
° 22·5	″ 9·76	6	0 16	″ 10·01	6	1 25
67·5	9·68	6	0 13	9·56	6	1 37
90	...	...	...	9·60	6	1 40
112·5	9·85	6	0 9	9·56	6	1 35
157·5	9·79	6	0 5	10·06	6	1 30
180	...	...	...	9·55	6	1 45

Observer: J.

			h m			h m
° 22·5	″ 9·19	6	23 55	″ 9·49		
67·5	9·20	6	23 57	9″·05, 9″·43	6, 6	$1^h\,18^m$, $1^h\,56^m$
90	...	...	...	9·49	6	1 52
112·5	9·11	6	23 58	9·38	6	1 15
157·5	9·17	10	0 0	9·35	6	1 13
167·5	...	...	...	9·56	6	1 54
180	...	...	...	9·59	6	1 50

Observer: L.

°	″		h m	°	″		h m
67·5	9·66	2	0 35	157·5	9·85	2	0 37

15-inch Stop, without Screen, Power 470.

Observer: B.				*Observer:* H.F.		
Angle.	Diam.	Obs.	Time.	Diam.	Obs.	Time.
°	″		h m	″		h m
22·5	9·38	6	0 59	9·43	6	0 50
67·5	9·37	6	1 2	9·90	6	0 46
112·5	9·46	6	1 5	9·70	6	0 42
157·5	9·42	6	1 9	9·62	6	0 40

Observer: J.

°	″		h m	°	″		h m
22·5	9·01	6	0 22	112·5	9·67	6	0 24
67·5	9·29	6	0 20	157·5	9·47	8	0 26

Grouping all these measures, for each observer, in regard to the apparatus, screen, power, and time, we find no trace of systematical differences, as change of contrast would have led to expect, and personality remains constant.

	H.J.	L.	B.	H.F.	J.	Time.
	″	″	″	″	″	h m h m
20-inch, 2 screens	...	...	...	9·83	9·38	22 5–22 40
20-inch, 1 screen	9·38	...	9·49	9·74	9·44	22 52–23 40
15-inch, power 210	...	9·76	...	9·74	9·34	$23^h\ 55^m$–$0^h\ 16^m$, $1^h\ 13^m$–$1^h\ 56^m$
15-inch, power 470	...	...	9·41	9·66	9·36	0 20– 1 9
Mean	9·38	9·76	9·45	9·74	9·38	
Mean error	...	...	0·04	0·04	0·03	
Number of measures	27	4	51	132	154	

We see that the mean errors are very small, each value there given being already a mean of many measures. The amount of personality of the measurers causes uncertainty in the value which should be concluded for the diameter of Mercury. Giving equal weight to every observation, the value 9″·52 is obtained, while equal weight to each observer gives 9″·54.

Grouping together all the observations at each position angle, we obtain the following table :—

	H.J.	L.	B.	H.F.	J.
°	″	″	″	″	″
0	9·30	...	9·53	9·77	9·24
22·5	...	...	9·38	9·73	9·23
45	9·53	...	9·58	9·80	9·66
67·5	...	9·66	9·37	9·71	9·24
90	9·00	...	9·25	9·48	9·41
112·5	...	...	9·46	9·70	9·39
135	9·68	...	9·59	10·03	9·54
157·5	...	9·85	9·42	9·82	9·33

Taking out the means for each observer, for the sake of comparison, the following residuals are obtained:—

	H.J.	L.	B.	H.F.	J.
°	− ″·08	...	+ ″·08	+ ″·03	− ″·14
22·5	...	...	− ·07	− ·01	− ·15
45	+ ·15	...	+ ·13	+ ·06	+ ·28
67·5	...	− ·10	− ·08	− ·03	− ·14
90	− ·38	...	− ·20	− ·26	+ ·03
112·5	...	...	+ ·01	− ·04	+ ·01
135	+ ·30	...	+ ·14	+ ·29	+ ·16
157·5	...	+ ·09	− ·03	+ ·08	− ·05

If there is anything in these figures more than is attributable to errors of observation, the diameter at 90° is the smallest, and the largest are at 45° and 135° respectively.

1914 *November* 12.

Observations of the Transit of Mercury, 1914 *November* 6–7, *at the Royal Observatory, Edinburgh.*

The weather proved favourable for observations, as the sky was clear from the early morning until $23^h\ 30^m$, when the Sun was obscured by a bank of clouds. This cleared sufficiently in time for the last contacts to be observed, although a thin film of cloud still persisted. A gentle westerly breeze prevailed throughout the day.

Grubb Equatorial: Aperture 15 *inches.*
(*Observer, J. Storey.*)

This instrument was used with its aperture reduced to 10 inches. The first external contact was not obtained, the limbs being too unsteady and the definition poor.

The first internal contact was well seen, the "black drop" phenomenon being very persistent, so that whilst the limbs seemed to be tangential at $21^h\ 59^m\ 47^s$ G.M.T., the connection between the limbs did not cease until 16 seconds later. (Power 244.)

With the apertures of 10 inches and 6 inches the image was carefully examined for halos or markings on its disc, but none were seen; on the contrary, one was impressed by the uniformity of its colour.

With the Filar micrometer measures of the horizontal and vertical diameters of Mercury were made at various times, but the definition was far from perfect.

For the second internal contact a thin cloud was covering the sky, but the phenomenon was easily seen, and the definition was quite good. The contact was noted on this occasion as "quite clean," no ligament of any kind being visible.

The limbs were unsteady at the second external contact, but the observation was considered fairly good.

Observed Times of Contact.

	h	m	s	
1st internal	21	59	47	G.M.T.
	22	0	3	,,
2nd internal	2	6	34	,,
2nd external	2	8	39	,,

Measures of Diameter.
Aperture 6 inches.

Time of Observation.	Hor.	No. of Measures.	Vert.	No. of Measures.	Observer.
d h	"		"		
6 23	8·44	3	7·94	3	J.S.
23¼	9·66	4	9·84	4	W.
6 23½	9·46	4	9·40	4	J.S.
	Aperture 10 inches.				
7 1¾	10·06	4	10·12	7	J.S.

Photo-visual Refractor by Cooke: Aperture 6 inches.
(Observer, R. W. Wrigley.)

This instrument was fitted with a Merz polarising solar eyepiece, the magnifying powers used being 100, 140, and 200. For the contacts the power of 140 was employed, with full aperture of 6 inches. At first contact the sky was clear, but the definition at the Sun's limb was poor, and the first external contact was too uncertain for the observation to be of value. At first internal contact the black drop was very much in evidence, and the connection between the planet and the limb persisted after geometrical contact might have been supposed to cease.

During the transit, a scrutiny was made of the disc of the planet, but no distinctive marking could be detected, nor any halo such as has been seen during some previous transits. No difference could be observed, however the magnifying power and the quantity of light transmitted by the eyepiece were varied.

After a cloudy spell of two hours, the sky cleared sufficiently for the last contacts to be observed. The Sun's limb was much steadier, but a thin film of cloud, by reducing the contrast, prevented the time of last external contact from being observed.

Observed Times of Contact.

	h	m	s	
1st internal	21	59	57	G.M.T.
2nd internal	2	6	31	,,

The Transit of Mercury, 1914 *November* 6–7.

By A. Fowler, F.R.S.

The transit of Mercury was observed under very favourable atmospheric conditions at the Imperial College, South Kensington (lat. 51° 29′ 50″ N., long. $0^m\ 42^s$ W.), except about the time of egress, when the Sun was partially obscured by thin clouds. An attempt was made to observe the contacts at ingress by the spectroscopic method, but at egress this method could not be employed as the chromosphere was not then visible. The instrument used was the Evershed spectroscope, attached to the 6-inch equatorial, all the adjustments having been made on the previous day, as it was expected that ingress would occur almost immediately after the Sun had risen above the Science Museum. The lower limb of the Sun had in fact scarcely become visible on the slit plate before the advancing limb of the planet was distinctly seen projected on the chromosphere. About a minute later it was judged from the disruption of the chromospheric arc that external contact had taken place; a few seconds afterwards the appearance of a dark streak along the spectrum, when the limb of the Sun was just within the slit, ensured that the contact was complete. It was found much more difficult to be sure of the moment of internal contact, as the reappearance of the Sun's bright limb at that point was not very sharply marked, perhaps on account of the small size of the image of the Sun on the slit (0·65 inch).

Egress was observed in the usual way by direct observation, using a solar diagonal eyepiece with power 100. The observations were unsatisfactory on account of cloud, and a large error in one of them is shown by the fact that the observed interval between the two contacts was much less than that calculated.

The observed times (G.M.T.), compared with those calculated from the data given in the *Nautical Almanac*, were as follows:—

		Calculated. h m s	Observed. h m s	
Ingress (spectroscopic)	External Contact	21 58 7	21 56 59	Possibly too early.
	Internal ,,	22 0 22	21 59 29	Somewhat uncertain.
Egress (telescopic)	Internal ,,	2 6 43	2 7 9	
	External ,,	2 8 56	2 8 44	Very uncertain.

At several times during the transit, the planet was observed in the telescope, the image being very steady and the definition extremely good. The disc appeared to be absolutely black, with a perfectly sharp boundary. No halo was noted about the planet at any time, and no bright spot on the disc itself such as has sometimes been recorded. With the spectroscope, an attempt was made to determine if there was any strengthening of telluric lines near the limb of the planet, but no effect of this kind was certainly observed; the observation, however, was rendered difficult by the small size of the image.

Observations of the Transit of Mercury, 1914 *November* 6–7, *at Armagh Observatory.* By J. L. E. Dreyer, Ph.D.

The morning was foggy and very damp, and the Sun was quite invisible until 25 minutes after the time of ingress.

At $12^h\ 10^m$ Greenwich M.T. Mercury was seen sharply defined, sky clear. A tiny white point was seen north of the centre, about one-third of the semidiameter from the circumference; very persistent. There was no halo round the planet, and the granulation of the solar surface was well seen close up to the limb of Mercury.

$1^h\ 45^m$. Bright dot not seen; Sun's limb boiling a good deal.

$1^h\ 52^m$. Bright point seen occasionally, but now it is in the centre of Mercury. It continued to be visible off and on as long as the planet was on the Sun.

Egress.

$2^h\ 6^m\ 35^s{\cdot}0$	G.M.T.	Black drop begins to form, but much fainter than body of planet.
$2^h\ 6^m\ 53^s{\cdot}0$	,,	Geometrical contact nearly.
$2^h\ 6^m\ 59^s{\cdot}0$	,,	,, ,, now; definition not as good as 2^h ago; some boiling.
$2^h\ 8^m\ 33^s{\cdot}0$	,,	Planet barely visible.
$2^h\ 8^m\ 37^s{\cdot}0$	,,	External contact certain now; definition good.

Instrument: 10-inch refractor, power 100, single surface reflection eyepiece.

1914 *November* 11.

An Efficient Slow-motion Gear. By W. S. Franks and J. S. Adams. (Plate 4.)

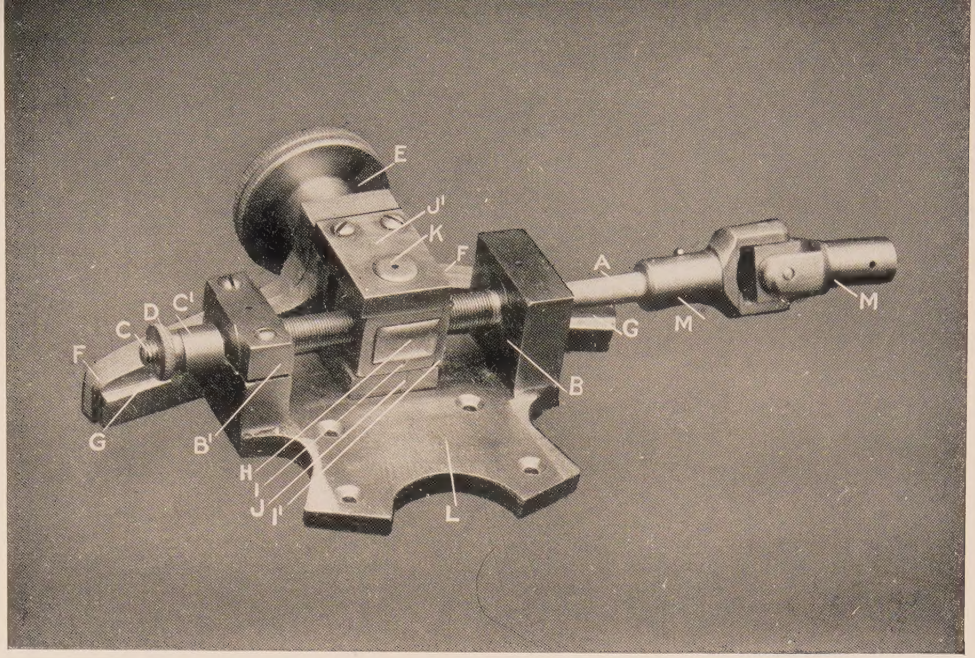
The accompanying photograph of a new slow-motion attachment on the $6\frac{1}{8}$-in. equatorial at Brockhurst Observatory may perhaps interest the Fellows. The old arrangement, with spiral spring to take up lost motion, was very unreliable and caused much loss of time in bisecting. The new one had to be fixed in the same place, on the arm carried by the polar axis, and clamping on a projecting rim of the 20-inch R.A. circle. As the slow-motion screw was on the chord of the arc, the nut had to be capable of some sliding motion along the radius to accommodate the varying distance at the centre or end of the arc; also some pivoting motion to allow for the change of angle. This was accomplished by enclosing the split nut (H) in a rectangular casing (I), having elliptical holes for the screw to pass through—so that it could move to and fro along the radius—the casing itself being carried by coned pivots

above (K) and below, giving the necessary angular motion, and working in thick plates (J, J′) projecting from the clamp boss, the upper one being adjustable. The clamping arcs are 5 inches long (instead of less than an inch previously), with guiding pins to preserve parallelism (FF and GG). The clamp head (E) is massive, and is really a nut working on a fixed steel screw—a very slight turn makes it grip firmly. The slow-motion screw (A) has 36 threads to the inch, working at one end in a coned bearing (B), whilst the other end bears against an adjustable thrust screw (C), with lock nut (D); the upper part of the bearing (B′) being also adjustable, and the lower part solid with the boss C′. The split nut (H) is of hard phosphor-bronze, and has adjusting screws; so also has the cover plate (I′) on the radius box. All other parts are of gun-metal, cast in as few pieces as possible; the screws are all steel, every moving part is ground to an accurate fit, and, of course, compensated for wear.

It only remains to say that the working of this gear gives great satisfaction, the motion being perfectly smooth and free from backlash. It was entirely designed and built in the Brockhurst workshops.*

*[I would like to add one remark to the foregoing, which is that Mr. Adams was entirely responsible for the mechanical details of this gear.—W. S. F.]

Mr. Frederick J. Hanbury's Observatory:
Brockhurst, East Grinstead.



SLOW-MOTION GEAR.

A. Screw shaft.
B. Coned bearing.
B'. Adjustable bearing.
C. End thrust screw, working in boss C'.
D. Lock nut.
E. Clamp head.
FF. Outer clamp arc.
GG. Inner clamp arc.
H. Split nut, sliding in I.
I. Rectangular casing.
I'. Adjustable cover for casing.
J. Lower pivot plate.
J'. Upper adjustable pivot plate.
K. Upper coned pivot.
L. Base plate, carried by arm on polar axis.
MM. Hooke's joint to slow-motion handle.